Homework #8, PHY 674, 8 November 1995

(X37). Find the character of the electric dipole operator $\vec{r}$ for the following symmetry groups: O, O_h, T_d, D_{2h}, D_{4h}. Are these characters irreducible ? If not, break them up into irreducible components.

(X38). Do the same for the magnetic dipole operator proportional to $\vec{L} = \vec{r} \times \vec{p}$.

(X39). For the groups T_d and D_{2h}, find all allowed electric and magnetic dipole transitions. Which of the phonons (at $\vec{k} = 0$) of $YBa_2Cu_3O_6$ and $YBa_2Cu_3O_7$ are infrared active ? Hint: A lattice vibration (phonon) is called infrared active, if its representation is contained in the representation of the electric dipole operator. In this case, the phonon gives you an infrared absorption band at the frequency of the phonon. If the phonon is NOT infrared active, it can either be Raman active, or silent.

(X40). A GaAs crystal has an FCC Bravais lattice with a basis of two atoms per unit cell. The cation (Ga) is located at the origin and the anion (As) is displaced along the (111) direction by one fourth of the length of the body diagonal. Find the point group of this system. Is the space group for this crystal symmorphic ? If not, find the non-primitive translations belonging to the point group elements. Does this group contain the inversion as a symmetry element ?

(X41). Do the same analysis for a silicon crystal, which has the same crystal structure as GaAs, but both atoms are the same.

For the cubic groups, use the notation and character tables from Bouckaert, Smoluchowksi, and Wigner, Phys. Rev. **50**, 58 (1936). (Otherwise, your results will not help you to read semiconductor band structures.) For D_{2h} and D_{4h}, use the notation from Tinkham and the subscripts g (gerade) and u (ungerade) for even and odd representations.

In order to do the problems studying the space groups of the zincblende and diamond structure, I suggest you consult the review article by Koster in Solid State Physics, Ref. [25] in the script (pp. 174, pp. 229).

All problems are worth 4 points, regardless of their difficulty.

Due Date:
Friday, 17 November 1993, 2:10 pm
in the green box in Room 12 (or in class).

Dr. Stefan Zollner, A205 Physics, 294-7327, November 7, 1995.
Send questions to: `zollner@iastate.edu`.